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New Doctoral Programme in Mathematics

by Sylvain Comeau

The Department of Mathematics and Statistics, in the Faculty of Arts and Science, proudly launched its doctoral programme this academic year. In the past, M.Sc. graduates in Mathematics who wished to continue to the doctoral level had to study at another university or pursue their Ph.D. in the School of Graduate Studies' interdisciplinary Special Individualized Programme (SIP).

There are currently nine doctoral students at Concordia: five in the new programme and four in the SIP. It is expected that a higher proportion will soon be enrolled in the Ph.D. programme, although some may still choose the SIP to conduct research which is interdisciplinary in nature. The launching of the new programme is very timely, with the demand for Ph.D.'s in Mathematics poised to accelerate, both in academia and industry.

The department first put together a proposal for a Ph.D. programme five years ago, and applied the simple laws of supply and demand in order to secure the best chance of gaining approval from the Quebec Ministry of Education. They chose, as the focus of the proposal, three research areas: mathematical physics, computational algebra and number theory, and dynamical systems.

The strategy was to get the programme in place focusing on these main areas and then to expand later. It is expected that the department's fourth main research interest, Statistics and Actuarial Mathematics, will debut in the programme next September.

Professor Ron Stern, Programme Director for the Ph.D., foresees eight students in the programme by next year, with that number to be maintained for the first few years. For the moment, Stern says the idea is that the programme should be "lean and mean". We're trying to select a small number of excellent students, and in the early stages we're not worried about the

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size of the programme. We want to have a quality programme, set up the structures, and get it rolling."

The faculty expertise is available to accommodate a greater number of students, but funding is limited. Ph.D. students have to be supported at about $14,000 a year, with much of the money coming from the research groups to which the students belong.

The new programme is likely to attract more students in general to the department, particularly talented and ambitious students who have set their sights on a doctorate. The department actively recruits overseas, and Concordia's math students come from all over the world.

The quality of the programme may also have a lasting impact on the well established master's programmes. There is already a blending of the two in some areas, since some courses can be taken by both master's and doctoral level students. The result may be an upgrading of the M.Sc.and M.A. programmes. "You could call it a trickle down effect from the doctoral to the master's and maybe even down to the honours undergraduate level", says Stern.

Centre of Excellence

The Institute of Mathematical Science (ISM), plays an important role in the new Ph.D. programme by helping to ensure that there will be enough students for every course. The ISM is a city-wide centre of excellence which provides graduate training by pooling the resources of the Departments of Mathematics and Statistics at Concordia, McGill, UQAM, Université de Montréal and École Polytechnique. The ISM facilitates coordination between departments so that duplication of course offerings at the doctoral level is reduced. In this way, a Ph.D. course given at Concordia, for example, would normally not be given anywhere else in Montreal at the same time.

The Institute also allows students to cross-register at another university under the supervision of a professor at that university. In this way, despite the small pool of graduate students, the ISM helps to ensure that there will be enough students to justify the existence of highly specialized courses. In the process, the ISM brings all math graduate programmes under one umbrella. Scholarships to deserving students are also offered by the five universities through the ISM.

Doctoral Students

Nathalie Stievenart, working with Professor **John Harnad**, is calculating non-linear wave propogation in optical fibres. This work holds tremendous potential for applications because of the growth of fibre optic communications. When a coded message is sent across a fibre optic cable, that message is transformed into an electrical signal which is propogated along the fibre. For her master's thesis, Stievenart worked out a mathematical model which could be used to examine how these waves behave. She says that this is a phenomenon which has never been computed before. For her doctoral dissertation, she is developing another solution to the same problem.

Stievenart may be the first graduate in the new programme. She has already completed a year in the SIP programme, but switched over to the new programme this year, and expects to graduate next year.

Vedim Lioubiomov also switched to the new programme from the SIP programme. His research in absolutely continuous invariant measures has many potential applications, for instance, in calculations on controlling animal population growth through feeding changes and on the spread of diseases at the molecular level.

Lioubimov came to Canada and Concordia University from the Ukraine two years ago because of the Department's reputation and expertise in dynamical systems. He obtained an M.A. in mathematics at Kharkov State University in Russia, and worked in computer science at the Engineering and Economics Institute in Kharkov and in pollution control at the National Institute of Water Protection in the Ukraine. Lioubimov published 20 papers while in Russia, including one which as been translated into English in the journal, *Programming in Computer Software.*

Ji Shuixin came from the city of Lan Zxou in the North West of

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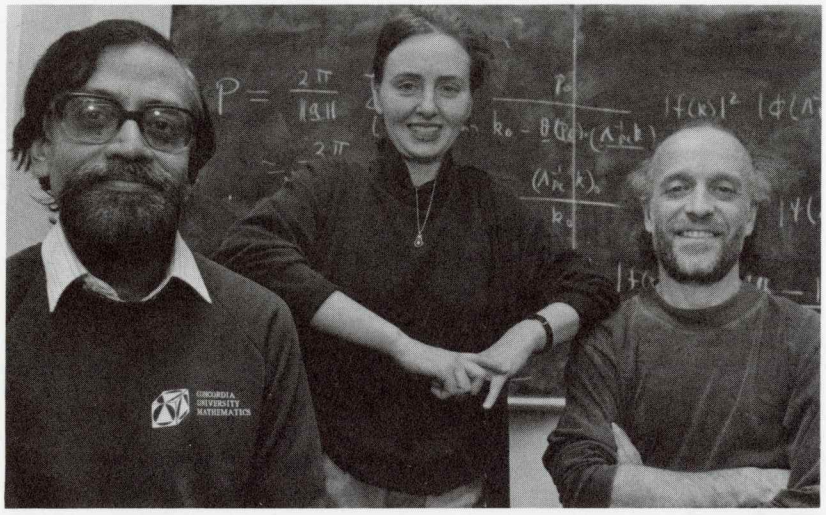

Professor S.Twareque Ali, N. Gravenor (graduate programme secretary) and Professor Ron Stern

China to pursue his master's studies in Statistics at Concordia. His master's thesis provided an extension and simplification of the Central Limit Theorem, which is central to probability and statistics. Ji says that the theorem is used in everything from Statistics Canada survey results to Loto-Québec calculations on the return from the 6/49 lottery. Ji's thesis was published in the Statistics and Probability Letter. Another paper on a related subject, the Poisson Theorem, has been accepted by the *Journal of Applied Probability*. Ji says his doctoral dissertation will likely also be on one of these theorems.

Ji also obtained a Master's in Mathematics in China, and has worked as a lecturer at Lan Zxou's North West Normal University, which trains high school teachers. While completing his Ph.D., Ji is working as a statistics tutor in the department.

Scholarship and Research

Research in mathematics is generally a process of formulating new concepts and methods, but that is the crux of a philosophical debate in the field. Some mathematicians believe that a new concept in mathematics is not an invention but a glimpse of a "mathematical reality" which already exists.

According to Dr. Syed Ali, who teaches mathematical physics at the Ph.D. level, there are two principle sources for new concepts in mathematics. The first is in applied areas, such as in mathematical physics. A physical phenomenon is studied in the laboratory or as it unfolds in nature, and researchers try to analyze it mathematically. Physical phenomena examined by mathematics can include anything from the probability of earthquakes to fluctuations in the stock market. If the existing mathematical concepts are not enough to tackle the problem, new techniques need to be invented. Historically, the physical world has been a major source for the formulae and concepts in the highly rarified world of mathematical theory.

The other source of mathematical inspiration is pure or fundamental mathematics itself. Existing mathematical structures become the foundation on which more complex or more powerful structures are built.

Concordia's mathematics professors and graduate students are working on both Applied and Pure Mathematics, with funding from NSERC (Natural Sciences & Engineering Research Council, a federal funding agency) and FCAR, a provincial funding agency and from Concordia's internal grants. In addition, some researchers have forged valuable industry links.

Professor **Syed Ali** is the director of the M.A./M.Sc. programme. At the doctoral level, he teaches Mathematical Physics, particularly in the areas of quantization problems and functional analysis. He is acting as thesis supervisor for SIP student, M.R. Karim.

In his research, Ali is working on quantization problems, using a branch of mathematics known as group theory. Group theory studies the symmetry of physical systems. Quantization is the method by which one arrives at a microscopic or quantum dynamics starting from its macroscopic or

classical counterpart. In 1990, Ali translated a book, *Quantique Rudiment*, from French to English. He has edited several books on *Quantization and Coherent States Methods*, and is currently writing two books on quantization problems. He has published extensively in the *Journal of Mathematical Physics*, *Annales de l'Institut Henri Poincaré*, and the *Physical Review* among others.

Professor **Yogendra Chaubey** belongs to the Statistics and Actuarial Mathematics research group and is supervising two Ph.D. students through the SIP programme: one working with faculty in the Departments of Psychology and Decision Sciences & MIS and the other with faculty in the Department of Decision Sciences & MIS.

His areas of current research interests include Bayesian Analysis and Multivariate Analysis. Some of these topics will be part of the graduate courses to be offered in coming years as part of the extension of the Ph.D. programme. In Bayesian Analysis, new evidence is incorporated into previously collected evidence combining objective and subjective information. The methods are general in terms of decision making and have applications in weather prediction and other forecasting problems.

Multivariate Analysis is a collection of techniques to deal with possibly a large number of variables and applications are in diverse areas including psychology, development of aptitude tests and quality control. Chaubey plans to teach a course on Variance Components at the Ph.D. level which deals with estimation or assessment of different factors contributing to the variation in the observations. This topic has potential application in animal breeding.

Chaubey is currently working in the area of survival analysis, which deals with estimation of different characteristics including the life expectancy of the inherent survival mechanism of a biological or mechanical system. This research is sponsored by an NSERC grant. Chaubey is about to publish a paper on the above topic in the international journal *Statistics and Decisions* published from Germany.

Professor **José Garrido** teaches actuarial mathematics and statistics at the graduate level. Stochastic probability examines and creates mathematical models for any phenomenon that evolves in time with a certain amount of unpredictable randomness, such as the price of a stock.

Garrido is currently working on a better way to create mathematical models for forecasting the cost of hurricane damage. The problem with such models up to now is that they assumed the same risk of hurricanes throughout the year, even though hurricanes occur more frequently during the summer. Garrido's model adds greater realism, since it will show varying levels of risk. Garrido's Ph.D. course will focus on this application as an illustration of the

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The Department chose three research areas as the focus of the doctoral programme: Mathematical Physics, Computational Algebra and Number Theory, and Dynamical Systems. A fourth area, Statistics and Actuarial Mathematics, will follow.

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The Institute of Mathematical Science (ISM) provides graduate training by pooling the resources of the Departments of Mathematics and Statistics at Concordia, McGill, UQAM, Université de Montréal and École Polytechnique.

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stochastic method he is using. A paper he wrote on that work has been accepted by the actuarial journal *Insurance Mathematics and Economics.* Garrido sits on the probability committee of the ISM.

Professor **Pawel Gora** teaches a course in dynamical systems at the doctoral level, currently focusing on Sharkowskii Theorem. In coming years he will focus on absolutely continuous invariant measures, one of his and Professor **Abraham Boyarsky's** research interests.

These are measures which can describe mathematically the behaviour of physical systems. One example Gora and Boyarsky have examined is drill bits; he says that mathematically measuring the behaviour of drill bits during use can lead to improvement in design.

Gora and Boyarsky recently wrote a book on Dynamical Systems, tentatively entitled *Laws of Chaos*.

Professor **Richard Hall** teaches a Ph.D. course in Spectral Geometry and acts as thesis supervisor for a doctoral student, Nasser Saad, who is working in the area of Mathematical Physics. Hall has been working on mathematical aspects of elementary quantum systems such as nuclei and hydrogen atoms. He has contributed to the *Journal of Mathematical Physics and Physical Review*, among others.

Professor **Hershy Kisilevsky**, who will be teaching algebraic number theory at the doctoral level, conducts fundamental research in these areas which can be applied, among other things, to error correction in very long distance communications. One example is signals sent to and from a spacecraft which often get distorted because of interference. Error correction can eliminate the distortion. Kisilevsky has worked on problems related to Fermat's Last Theorem, which was solved last year. He has published in the Journals of *Number Theory* and *Compositio Mathematica*, among others, and edited two conference proceedings published by the American Mathematical Society.

Professor **Ron Stern** teaches non-linear dynamical systems and non-smooth analysis at the doctoral level. He is conducting research in that area with a student through the ISM, and expects that a Concordia student will soon join his team. Traditionally, much of the theory of dynamical systems assumed that systems evolve in a linear (straight) and smooth way. Non-linear and non-smooth methods try to encompass a certain roughness, a sharp unpredictability in processes which evolve in time, for example the weather, a market economy, or a flying airplane. This work has applications in control theory. Stern is working on the construction of feedback controls in control systems. Non-linearity and non-smoothness lend themselves very well to the construction of algorithms for these control functions.

Stern recently published an article in the *Canadian Journal of Mathematics* on a new kind of generalized calculus using non-

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smooth analysis, and an article in the journal, *Non Linear Analysis,* which extends the classical results of fixed point theory. He co-authored a book in 1989, *Non-negative Matrices in Dynamic Systems.*

For further information on the Department's graduate programmes, please contact:

Graduate Programme Director
Dept. of Mathematics & Statistics
Concordia University
71741 Sherbrooke St. W.
Montreal, Quebec H4B 1R6
Tel: (514) 848-3250
Fax: (514) 848-2831

Editorial Committee:
Chair: D. Markiewicz
Editor: D. MacFadden
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Location:
2145 MacKay Street
Telephone:
(514) 848-3808
Fax Number:
(514) 848-2812

UPCOMING DOCTORAL EXAMINATIONS

BOILEAU, Paul-Emile
Mechanical Engineering
DATE: Monday, April 3, 1995
TIME: 9:30 a.m.
ROOM: H 769
TITLE: *A Study of Secondary Suspensions and Human Driver Response to Whole Body Vehicular Vibration and Shock*

JOSEPH, Norma, Religion
DATE: Monday, April 3, 1995
TIME: 2:00 p.m.
ROOM: H 771
TITLE: *Separate Spheres: Women in the Responsa of Rabbi Moses Feinstein*

KIM, Young-Soo
Mechanical Engineering
DATE: Wednesday, April 5, 1995
TIME: 10:00 a.m.
ROOM: H 773
TITLE: *Biaxial Buckling of Laminated Composite Plates*

GADOSY, Timothy, Chemistry
DATE: Thursday, April 6, 1995
TIME: 2:00 p.m.
ROOM: H 771
TITLE: *Stabilization by Natural and Unnatural Cyclodextrins of the Transition States of Acyl Transfers of Nitrophenyl Alkanoate Esters*

BARUZZI, Guido
Mechanical Engineering
DATE: Friday, April 7, 1995
TIME: 1:30 p.m.
ROOM: ER 301
TITLE: *A Second Order Finite Element Method for the Solution of the Transonic Euler and Navier-Stokes Equations*

BATTA, Vinod, Civil Engr.
DATE: Friday, April 7, 1995
TIME: 10:30 a.m.
ROOM: ER 303-2
TITLE: *Two-Dimensional Boundary Element analysis of Seismic Cracking in Concrete Gravity Dams*

CHAABAN, Mohamed
Mechanical Engineering
DATE: Monday, April 10, 1995
TIME: 9:00 a.m.
ROOM: ER 301
TITLE: *A Finite Element Calculation Method for the Heat Transfer Effects on the Current-Carrying Capacity of Underground Electrical Cables*

YUAN, Xidong, Civil Engineering
DATE: Monday, April 10, 1995
TIME: 10:00 a.m.
ROOM: H 769
TITLE: *Computer Vision Techniques for Traffic Data Collection and Analysis*

ZARGARI, Navid
Electrical & Computer Engineering
DATE: Monday, April 10, 1995
TIME: 10:00 a.m.
ROOM: H 773
TITLE: *AC/DC Power Conversion Schemes with Unity Power Factor & Minimum Harmonic Distortion*

LI, Lin, Civil Engineering
DATE: Tuesday, April 11, 1995
TIME: 2:00 p.m.
ROOM: ER 303-2
TITLE: *Analysis of Tall Building Tubular Structures by Finite Story Method*

XIAO, Shuyong, Chemistry
DATE: Tuesday, April 11, 1995
TIME: 2:00 p.m.
ROOM: H 771
TITLE: *Preparation and Characteriazation of Solid Acidic Catalysts for the Hydrocracking of n-Paraffins*

OUESLATI, Faisal
Mechanical Engineering
DATE: Monday, April 24, 1995
TIME: 2:00 p.m.
ROOM: H 769
TITLE: *An Analytical Investigation of Passive & Active Suspension Systems for Articulated Freight Vehicles*